Volume 2, Issue 5
May I 2024

Agri Roots
e- Magazine

www.agrirootsmagazine.in

ISSN: 2583-9071

Microplastic: Scenario in India

ARTICLE ID: 0094

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The distribution and impacts of plastic debris, particularly microplastics (MPs), in diverse natural habitats have been the focus of India's attention. MPs are small plastic particles with a diameter of 1µm-5mm that have entered aquatic, terrestrial, and atmospheric environments. They are released through primary or secondary sources, such as fragmentation of plastic waste in aquatic environments, scuffs in vehicle tyres and plastic coatings (Sau et al., 2023). Wastewaters also contain a large number of MPs, including synthetic textile fibers from laundry, polyethylene microbeads from cosmetics, and disintegrating components of larger consumer objects flushed down the toilet. MPs in the environment come in various sizes and shapes, with the majority having irregular shapes, such as pieces, fibers, or films. Microplastics have gained attention for their safety and toxicity, potentially linking them to invasive species and environmental issues. Their small size allows them to be internalized by biota, accumulating in the food chain and adsorbing pollutants on their surfaces. However, microplastics can also carry hydrophobic organic contaminants through ingestion, absorption, or increased excretion. These pollutants penetrate through gill membranes and both direct and indirect nutritional intake of prey, posing a serious environmental problem. Despite these potential risks, the presence of microplastics remains a significant concern for ecotoxicologists (Anbumani and Kakkar 2018).

Microplastic Pollution

Microplastics represent a substantial health concern to both in vivo and in vitro systems since they are newly discovered pollutants with a high potential for bioaccumulation (Anbumani and Kakkar 2018). Many freshwater creatures, such as fish, birds, mammals, and plankton, may consume these little particles, which then build up throughout the aquatic food web. The

adsorption of organic pollutants from the surrounding medium by chemical additives found in plastics, such as flame retardants, antistatic agents, plasticizers, heat stabilizers, acid scavengers, thermal stabilizers, and slide compounds, exposes animals to toxicants more often (Hahladakis et al., 2018). These additions can be generically categorized as colorants, fillers, reinforcements, and functional additives. Aquatic environments are threatened by hydrophobic persistent organic pollutants, which have been demonstrated in fishes of marine environment in a controlled laboratory environment using microplastics as vectors.

The fibres and film sheets of microplastics, which include foam plastics, plastic pellets, films, granules, microfibers, and other materials, are what define those (Rodrigues et al., 2019). They are found in greater abundance in lotic and lentic sediments, which may have come from washing clothes in municipal sewage effluents. Polypropylene, polyethylene, polystyrene, polyvinyl chloride, and polyethylene terephthalate are among the materials that may be used to make microplastics. The quality of plastics is impacted by the inconsistent separation and identification processes caused by their varied kinds, sources, and environmental degradation processes (Lahens et al., 2018).

Scenario of Microplastic In India

One-third of people in India reside along its 8000 km long coastline. Prominent industrial centres including as Chennai, Kochi, Kolkata, Mumbai, Visakhapatnam, and Surat are situated in close proximity to the coast, contributing significantly to the generation of plastic garbage (Veerasingam et al., 2017). By entering the maritime environment through bays, streams, and rivers, these wastes endanger coastal resources and ecosystems. Mumbai is one of the major cities that releases a lot of plastic garbage into the coastal waterways every day; other important cities that experience plastic pollution include Kolkata, Chennai, Visakhapatnam, Gujarat, Pondicherry, and Gopalpur (Nanthini et al., 2023). India contributed 8.33 million metric tonnes of plastic pollution yearly, bringing the total to 367 million metric tonnes worldwide in 2021 (Jambeck et al., 2015). India uses a lot of polyethylene and polypropylene as raw materials for microplastics. Ahmedabad, Mumbai, and Kolkata produce the most of these materials (Veerasingam et al., 2016a). Gujarat, the coastline of Chennai, the beaches of Mumbai, and Kerala Lake all have significant accumulations. Water samples have also been discovered to contain microplastics, with the highest concentrations of plastic particles recorded in Delhi, Mumbai, and Chennai. Microplastics have also been found in Indian estuaries and sediments around Vembanad Lake. The effectiveness of bacterial isolates obtained from the Vaigai river in India to degrade microplastics was assessed by Nanthini et al., 2021.

Terrestrial Ecosystem

As pollution from human activity increases, there is rising worry about plastic contamination in terrestrial habitats. Concerns regarding particle-induced toxicity and chemically-induced toxic symptoms during leaching are raised by the growing amount of microplastics (MPs) in the environment (Huerta et al., 2016). According to certain research, the presence of MPs may result from the physical or chemical breakdown of bigger plastic particles into smaller ones. Year 2010 saw the production of 275 million tonnes of

plastic garbage, of which 4.8–12.7 million were disposed of in the ocean; the remainder amount was left in the terrestrial environment, suggesting a greater environmental load. For the drilosphere process to continue sustaining soil fertility, soil organisms are essential. According to recent research, there may be a negative relationship between MPs and soil biota that affects the behaviour and health of terrestrial species (Lwanga et al., 2017). The improper removal of plastic garbage, the using landfills to dispose of sewage sludge, human littering, and the contamination of agricultural land by sewage sludge application are some of the pathways through which microplastics (MPs) can enter terrestrial environments. These pathways can impact MPs' fate, retention, occurrence, deprivation, and conveyance. As plastic debris builds up on land, it is discharged into freshwater and marine environments. Additionally, washing textiles generates MP fibres, or microplastics, which damage aquatic life and alter freshwater ecosystem dynamics (Mai et al., 2018).

Marinewater Ecosystem

Oceans all across the world are home to microplastics, which serve as a sink for plastic waste. Studies indicate that they can be found in surface waters, biota, beaches, and the water column. Large ocean currents cause water columns to amass more microplastics (Anbumani and Kakkar 2018). During high tide, between 50 and 300 plastic particles per square metre were found along Caranzalem beach in Goa. There were found to be 68.83 particles/square metre, ranging in size from 1 to 20 mm, in Mumbai, India. Plastic pellets (sizes ranging from 1200 to 3000) with a particle size of 2.5 mm were discovered on the beaches of Goa and Chennai (Veerasingham et al., 2016b). These results emphasise how critical it is to solve the global problem of microplastics in seas. Despite the belief that the number of microplastic particles increases with universal plastic production and consumption, a newest study revealed no appreciable change in the concentration of microplastics in the marine environment of the Baltic Sea ecosystem over the previous three decades (Beer et al., 2018). Microplastics detection in biota is not limited in natural conditions. The research indicates that rather than being solely reliant on global plastic production and consumption, the amount of microplastic contamination may be directly linked to certain human activities.

Freshwater Ecosystem

There are microplastics in lakes, rivers, and estuaries, according to recent studies. Freshwater resources in India are not known to contain microplastic particles. In addition to direct effluent discharge from waste water treatment plants, microplastics can also reach the environment by dissolving in water columns and leaching from land into water basins. Near urban and touristic locations close to freshwater habitats, they are more prevalent. Microplastic particles from freshwater resources in India have not been identified. Industries in coastal areas contribute to significant plastic load into the sea (Anbumani and Kakkar 2018). A Swedish harbor area reported approximately 100,000 plastic particles m−3 near a polyethylene production plant. A significant correlation was observed between densely populated areas and plastic load across six continents. Studies demonstrating the presence of MPs in estuaries, rivers, and lakes indicate that MP pollution

poses a serious danger to freshwater biota. Plastic particles may degrade and seep into the environment as a result of industrial, residential, and wastewater treatment plant effluent discharge (Browne et al., 2011).

Investigations in The Indian Ocean

Microbes quickly colonize marine plastics when they are introduced into marine habitats, creating microbial biofilms on surfaces that contain water, nutrients, carbon, and energy (Wright et al., 2020). The way that these materials interact with their surroundings can be influenced by these biofilms, which are present on all natural surfaces. The formation of complex three-dimensional structures and extracellular polymeric substances (EPS) makes biofilms highly persistent microbial colonies that can withstand harsh environments (Xu et al., 2017). Plastic waste enters the global ocean annually, with 15% entering the Indian Ocean (Schmidt et al., 2017). NOAA data shows 4,291 macroplastic items in the Indian Ocean, Mediterranean Sea, North Pacific, South Atlantic, and South Pacific according to visual survey transects.

The Indian Ocean is home to up to 20% of riverine and 15% of coastal plastic, with the concentration of plastic pollution significantly influenced by river inflows. The Ganges, the second-most polluted river that runs alongside the seashore, releases 0.10-0.17 million tonnes of plastic into the Bay of Bengal annually (Roman et al., 2022). The combined Ganges, Meghna, and Brahmaputra rivers could release up to 1-3 billion MPs into the Bay of Bengal daily. The Bay of Bengal, along with the Eastern part of the Arabian Sea, is the largest coastal and riverine source for plastic pollution in the Northern Indian Ocean (Thiemann 2023). Plastics enter the marine environment through different river estuaries to varying degrees. Storm occurrences in a tiny seasonal river near Cape Town, South Africa, left trash stuck within 0.5 kilometres of the river mouth. It was discovered that the Punnakayal estuary in Chennai had up to 19.9 MPs per L of pollution, suggesting that MPs might be transported from inland regions to the Gulf of Mannar via this estuary (Selvam et al., 2021). According to Manickavasagam et al. 2020, a significant amount of the plastic trash carried down the South Juhu Creek from densely inhabited regions to the oceans was made up of macroplastic, which can ultimately convert the material into plastic. The Indonesian throughflow from the North Pacific may transport a significant amount of MPs to the Indian Ocean, primarily through fresh surface waters. However, MP abundances and types vary along E-W transects in the Indian Ocean, suggesting regional or local origins rather than solely from large river sources and low-salinity surface water.

Conclusion

India has a high population density and is the second most populated country in the world. Studies that have been published indicate that the marine environment in India is becoming more and more contaminated by microplastics. In India, the absence of scientific solid waste treatment poses a significant obstacle to future plastic pollution mitigation. The current article has finally concluded that there is a much higher level of microplastic contamination in the Indian marine environment than there is on average globally. If this issue is not addressed in a way that is both appropriate and grounded in science, there will be serious risks to

both India's marine resources and the global environment.

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